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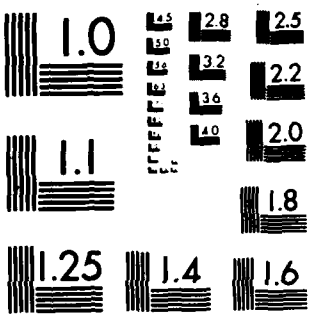

THE ARMY'S ACTIVITIES IN ARTIFICIAL INTELLIGENCE/ROBOTICS

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Abstract

A historical summary of the Army activities in artificial intelligence and robotics (AI/R) in the last one and one-half years indicates Army interest in AI/R from the laboratories to the Secretariat. Numerous funded and unfunded efforts are now planned by the laboratories even though AI/R technologies lack maturity necessary for autonomous battlefield systems in the 1990's. The potential applications of AI/R systems to Army needs appear to be limitless. DARCOM and TRADOC have prioritized AI/R requirements and plans for five high priority Demonstrators have been prepared. These demonstrators reflect the need to get started with todays technologies. Technological enhancements provided by additional research and development can provide additional autonomy in product improvement phases of the system development cycle.

Introduction

For the past one and one-half years the Army has been reviewing potential applications and needs for artificial intelligence and robotics (AI/R) that could enhance its operational capabilities. What began as a Headquarters, Department of the Army (HQDA), exploratory request for information about potentials of these rapidly emerging technologies appears to have grown to a general awakening to potentials throughout the Army. The objective of this presentation is to outline the Army's activities in AI/R in the past year and one-half which lead to this awakening. The activities to be reviewed are considered to be of interest to those attempting to follow the Army AI/R program. It is hoped that this paper is a credit to the many military and civilian personnel in the Army that participated in the AI/R activities. It must be realized that there were a very large number of AI/R related activities on-going within the Army laboratories which were not considered in the scope of this brief summary.

At the outset it should be cautioned that the perceptions are those of the author and should not be interpreted as necessarily representing the official views or policies of the Army.

Like any large organization, the Army must plan for the future. The Army's business is concerned with preparedness for ground combat. Its planners must continually strive to provide the combat organizations with weapons, materiel, and training that are necessary and sufficient to operate effectively in land combat in the next 20 years. Results of this planning generate training objectives, doctrine for employment of troops and weapons against an enemy force, and requirements for weapons and equipments development. Planning occurs at all levels in the Army. Overall coordination is the responsibility of HQDA. They provide the executive functions for the Army organization. Below HQDA, the laboratories provide research and development capabilities based upon requirements generated by the Schools and Centers of the U.S. Army Training and Doctrine Command (TRADOC), which represents the Army's user community.

Analysis of the Soviet threat indicates that their strength lies mainly in numbers. The U.S. Army forces are out-gunned and out-manned by more than 4 to 1 in the European Theater. It is no secret that the Soviets are spending more than the U.S. in an attempt to provide their forces with weapons they believe are needed for future combat. It is clear that the U.S. Army must find force multipliers if it hopes to complete successfully. We need better weapons, better trained troops, and effective means to coordinate and conduct the battle with sophisticated weapons against an enemy of superior numerical strength.

American high technology is expected to provide the basis for the force multipliers. It is said that America leads the Soviets by at least five years in the fields of microelectronics and computer technology. These fields will provide many of the candidates for our force multipliers. To be a candidate the weapon system must be less expensive, simpler to operate and maintain, and more reliable than that which is to be replaced. A weapon that requires a group of PhDs to operate and maintain is not acceptable. This would seem to indicate the need for weapons with a high degree of automation. Such weapons might be those which can be directed by a few commands and which relieve the operator of mental

and/or physical burdens and yet provide the desired service or effect. These functional requirements provide the motivation for investigating applications of AI/R to Army mission areas.

Definitions

What are the definitions of AI/R for the Army's needs? This is not an easy question to answer. Individual and organizational perceptions of artificial intelligence and robotics differ widely. Definitions provided by professional organizations are very controversial or limiting. Working definitions or their equivalent must be provided if different levels within a large organization are to judge if the new subjects falls within their mission area. It was determined that operational concepts rather than definitions would lead to more productive thinking in terms of potential Army applications and needs.

Robotics

Two common definitions are: (1) Webster's Third new International Dictionary which gives the following - "Robotics - technology dealing with the design, construction, and operation of robots in automation", and (2) Robotics International of the Society for Manufacturing Engineers provides the following - "An industrial robot is a programmable multifunctional device designed to both manipulate and transport parts, tools, or specialized manufacturing implements, through variable programmed paths for the performance of specific manufacturing tasks." Since todays common perception of robotics usually involves manipulators in industrial applications these definitions are popular.

The Army has a Manufacturing Methods and Technology (MM&T) Program, managed by the Directorate for Manufacturing Technology in the Headquarters, U.S. Army Materiel Development and Readiness Command (DARCOM), which addresses in part the use of industrial robotics in government-owned government-operated and government-owned contractor-operated facilities. This program is addressed elsewhere in these proceedings, by Mr. Fred Michel, Director of the Army MM&T Program.

The definition of robotics for the Army in the field must be more inclusive to allow sensors and mobility, in addition to manipulators and computers. But rather than concoct another definition, if one thinks of unmanned reconnaissance vehicles, mobile weapons platforms, or resupply vehicles as robotic machines, the essential flavor of the Army robotics has been captured.

Artificial Intelligence

The concept of artificial intelligence is more difficult to communicate. The AFIPS Taxonomy Committee, in their report entitled, "Taxonomy of Computer Science and Engineering," dated 1980, gives the following definition: "Artificial Intelligence - The study of how to make computers exhibit behavior that is considered 'intelligent' when observed in humans; includes the study of how to make computers perform tasks that, until recently, only humans could perform and the construction and study of computer executable models of human intelligent behavior." This definition, while correct for the academic world, is unsatisfactory and usually provokes a negative reaction from the uninitiated who in general believe computers to be useful for only number crunching. A more useful approach is to cast artificial intelligence as advanced computer software applicable to classes of nondeterministic problems such as natural language understanding, image understanding, knowledge engineering, expert systems, knowledge acquisition and representation, heuristic search, deductive reasoning, planning, etc. Examples from diagnostic programs such as MYCIN and PROSPECTOR or a system configuration program such as RI can punctuate the concepts. The concepts can then be mentally reformatted into Army problems such as diagnostics for equipment maintenance or communication network configuration, even though the existing programs might not be directly applicable.

AI/R

When the above has been said, the concept of AI/R relating to intelligent machines follows somewhat naturally. A word of caution must be added to indicate that artificial intelligence is only beginning to emerge from the basic research stage. This then leads to three categories of AI/R machines: (1) Unintelligent Machines - typically mechanical devices capable of being programmed to perform manual tasks; (2) Semi-intelligent Machines - systems that intake large quantities of data, processes and combines that data in a semi-autonomous manner to produce tailored actions or outputs; and (3) Intelligent Machines - Semi-autonomous and autonomous machines with the ability to reason abstractly, solve problems, and make intelligent decisions. This allows one to talk about evolving from a teleoperated vehicle to an autonomous vehicle through an R&D program.

The final definitional concept indicates the breadth of AI/R machines. An AI/R machine may be mostly AI, such as an intelligent data base query system, or mostly R, such as an automatic weapons loader.

Army AI/R Activities

For the purpose of this presentation the Army AI/R activities began in March 1981. This is not an arbitrary date, however its selection does neglect numerous preceeding activities which could be placed in an Army AI/R category. Someday someone may undertake the task of delineating the host of earlier activities. For now however we want to look back from the present through a series of activities that began in March 1981 with a few questions. (The questions that appear in Table 1 were not formally asked but they do point in a few words to the essence of periods in Army AI/R activity.)

Table 1. Army AI/R question chronology

Q1.	What applications and what plan?	Mar 1981
Q2.	What is happening now?	Jun 1981
A3.	I can do this!	Jul 1981
Q3.	What can we do?	Aug 1981
Q4.	What does the user want?	Aug 1981
Q5.	What is worth doing?	Oct 1981
Q6.	Why so many?	Apr 1982
Q7.	Can we begin with these few?	Jun 1982
Q8.	What else is there?	Jul 1982

The events and activities relating to Army AI/R were time ordered. For this reason the discussion to follow will be presented in the form of a historical summary rather than a separate discussion of each activity. As the series of activities (questions) are discussed it should be realized that individual efforts (answers) were not always complete before the subsequent activity began. Many of the concurrent activities seemed to have a synergistic effect.

Q1. What applications and what plan?

In March 1981 the Assistant Director for the Army Research Programs (Dr. Frank D. Verderame) in the office of the Deputy Chief of Staff for Research, Development and Acquisition (DCSRDA), HQDA, tasked the U.S. Army Engineer Topographic Laboratories (USAETL) to prepare a baseline R&D plan for AI/R by September 1982. The objective was a definition of R&D efforts leading to systems that could assist combat and combat support personnel in the field. Within USAETL a team of six engineers and scientists was formed to answer question 1. Early on it was decided that the task should be divided into two parts. The first part would be a contract study resulting from a competitive procurement. The study would be completed in time for the AI/R team to add supplemental material to the contract report if needed before submittal to DCSRDA in September 1982. The second part involved the in-house study team activities.

In early June the contract package was completed and submitted for competitive procurement. The contract statement of work had four tasks to be performed. They were:

a. From Army concepts and doctrine for the 1990's and beyond, such as the Army and TRADOC Mission Area Analysis Studies, or technological opportunities, identify significant categories of potential Army applications for AI/R which may assist Army combat or combat support personnel. Present detailed examples of potential AI/R systems within each category. Define in detail AI/R design criteria for the application categories.

b. Define in detail the state-of-the-art of AI/R technology for 1980 and extrapolate to 1990 and 2000 in each application category.

c. Detail an Army research plan through the year 1990 and a generalized plan to 2000 for each category which considers, for example, risks, cost/benefit, schedules, priorities, etc.

d. Identify the potential for initiation of developments (e.g., 6.3, 6.4) based on the natural and accelerated state-of-the-art.

In addition, the contractor was to present three review briefings during the period of the contract.

Q2. What is happening now?

AI/R was becoming a popular subject within DCSRDA and numerous requests for information lacked readily available answers. Dr. Verderame decided to prepare a briefing of current AI/R activities in the Army and elsewhere. This began in June 1981 and in two weeks a briefing package was prepared which put known on-going Army AI/R activities in perspective with that of the other armed services. The briefing package was notable for a number of reasons. It outlined seven major interest areas to cover the Army's primary needs in AI/R. These dealt with helicopters, tanks, artillery, air defense, manufacturing, maintenance, and training. For each area a set of desired functions was indicated. As an example, tanks: fire on the move; day/night/all-weather mobility/fighting capability; communication/command/control; NBC button down; navigation/position location; ammunition handling; and survivability/counter fire. Another example, artillery: improved target acquisition at extended ranges: multiple capability for target acquisition; surveillance weapons guidance/designation; ammunition handling; and increased mobility/survivability. These were terms readily understood by the Army staff.

The briefing package also contained the following AI/R examples arrange by relative time for an item to be demonstrated.

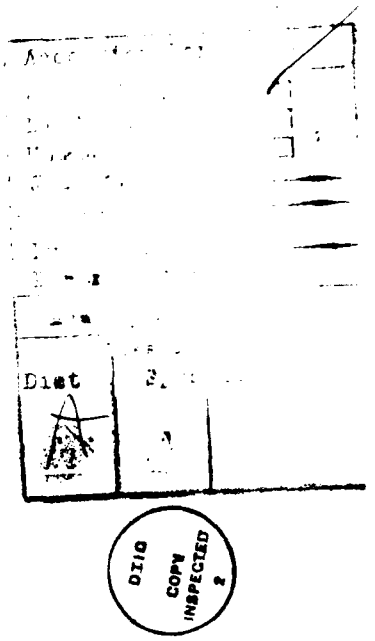
Table 2. AI/R examples in DCSRDA briefing package

NOW - Remotely piloted vehicles (teleoperated)
- Advanced TOW weapons (teleoperated)
- Laser designated weapons (teleoperated)
- Landmine clearing (teleoperated)
- Teleoperated bulldozers
- Computer-assisted training devices

NEAR TERM - Unintelligent Machines
- Automated munitions handling
- Automated loaders and unloaders
- Automated warehousing
- Teleoperated chemical decontamination
- Helicopter display and warning systems
- Computer-assisted training devices

INTERMEDIATE TERM - Semi-Intelligent Machines
- Helicopter flight assistant
- Semi-autonomous RPV target aquisition system
- Unattended forward observer
- Expert maintenance systems
- Manufacturing (GOCO, GOGO plants)
- Computer-assisted training devices

LONG TERM - Intelligent Machines
- One-man helicopter
- Two-man tank
- One-man self-propelled artillery piece
- Automated message analysis and distribution
- Semi-autonomous air defense systems
- Natural language query to C3I data bases
- Computer-assisted training systems



The briefing package contained observations and recommendations. Observations included: (1) The field of AI/R is emerging extremely fast in DoD. While each service has its manufacturing-related efforts that utilize extensions of current industrial robotic techniques, the bulk of the efforts relate to assisting combat personnel by reducing the workload with advanced information processing techniques and handling systems. (2) The Army efforts in AI/R are too sparse and too little to make any major impact. Recommendations indicated that the Army should act immediately to develop an Army AI/R program. Then prioritized areas for R&D were indicated.

This package was briefed at high levels in the following few weeks and reproduced copies were freely distibuted by Dr. Lasser, Director of Army Research, DCSRDA, HQDA. In retrospect, this package was responsible for launching AI/R in the Army in a coordinated manner. It commanded interest and attention within the Army Secretariat, HQDA, TRADOC, and DARCOM.

A3. I can do this!

This is an answer advanced prior to the question. On July 15, 1981 at Fort Knox, Kentucky, a congregation of military and civilians assembled to witness the Remote Control

Vehicle Special Evaluation Demonstration. Two remote controlled vehicles were highlighted in a simulated combat combined arms mission. The objective was to demonstrate the ability to locate an enemy minefield, breach the minefield, proof the breach, and mark the cleared lane with an unmanned remotely controlled countermine vehicle supported by a remotely controlled mobile weapons platform using state-of-the-art technology and existing hardware. The demonstration was conducted by the U.S. Army Armor and Engineer Board and sponsored jointly by the U.S. Army Armor Command, the U.S. Army Engineer School, and the U.S. Army Training Support Center with their General Officers in attendance. They are Lieutenant General Wagner, Major General Noah, and Brigadier General Sunell, respectively.

The scenario had an M114 armored personnel carrier moving into position in front of enemy forces situated at the edge of a dense forest stand. Between the enemy and the M114, a minefield would be discovered and the M114 would launch smoke grenades to cover the countermine vehicle movement. The countermine vehicle consisted of a M60 chassis (minus tank turret) with a mine roller assembly to the front, a rocket delivered line charge explosive mounted on top, and a cleared lane marking system mounted on the rear. As the countermine vehicle entered the minefield its roller would detonate a mine. The vehicle would then move back, fire the line charge so that it came to rest extended through the minefield, detonate the line charge to breach a cleared path, and then move along this path dropping markers.

A number of notable features resulted from the successful demonstration. Yes, teleoperated vehicles had been demonstrated in the past, but not in such a complex scenario. TV cameras mounted on the M114 allowed the operator in a remote position to locate and fire upon (and hit) a target while the vehicle was moving. Likewise, the sequence of actions to control the countermine vehicle through its set of tasks from a remote position by way of a TV link was not trivial. But the major achievement of the demonstration was the fact that it was successfully staged in a period of two months with off-the-shelf technology. Brigadier General Sunell suggested the demonstration in April 1981. At the time he also suggested two follow-on phases: Phase II would introduce some robotic functions but retain a human control link and Phase III would develop a totally autonomous vehicle. The five General Officers who attended the successful demonstration were asked by General Sunell at the conclusion of the demonstration to seriously consider generating user requirements to provide continuing developments of the robotics technology.

Q3. What can we do?

At the end of July 1981 a sufficient number of Army executives, military and civilian, were acquainted with and supportive of AI/R. DCSRDA called for an AI/R Planning Meeting on 5 August 1981. The meeting was held to initiate consideration for a coordinated Army R&D plan for AI/R. Attendees included representatives from DCSRDA, DARCOM, and the "little three", which were Office of the Chief of Engineers (OCOE), Deputy Chief of Staff for Personnel (DCSPER), and the Office of the Surgeon General of the Army (OSGA). The attendees agreed to serve as members of an Army Steering Committee for AI/R and Dr. Verderame was appointed Chairman. It was agreed that an Army AI/R Plan should be prepared and responsibilities were tentatively assigned. The Plan was scheduled to be prepared by December 15, 1981.

On August 15, 1981, a tasking letter was sent from DCSRDA to DARCOM and the "little three" requesting each organization to accomplish its responsibilities according to the Steering Committee recommendations.

Q4. What does the user want?

Prior to the formation of the Army AI/R Steering Committee, DARCOM had appointed the U.S. Army Human Engineering Laboratory (HEL) as their point of contact for robotics. It was HEL's task to poll all DARCOM laboratories for on-going and potential new initiatives in AI/R. TRADOC in the meantime appointed the U.S. Army Soldier Support Center (ASSC) as their point of contract for AI/R. Since DARCOM represents the bulk of the Army's system development capability and TRADOC represents the Army user community that generates requirements for system developments, their cooperation in AI/R was considered essential. On August 27, 1981, a joint meeting was held between DARCOM and TRADOC personnel to scope an effort leading to a joint AI/R plan from the DARCOM Laboratories that would have TRADOC prioritization. This joint meeting was seen as a positive indicator of the state of AI/R in the laboratories, Schools and Centers. It resulted in a TRADOC-DARCOM AI/R Steering committee jointly chaired by Major General French, Commanding General ASSC, and Dr. John Weisz, Director, HEL.

Q1. Revisited (contractor selected)

In the last weeks of September 1981, SRI International (SRI) was selected as the

contractor for the Army AI/R study. Their expertise in the fields of artificial intelligence and robotics coupled with their experience in Army-related programs and assembling large R&D programs for the government indicated that they had the capability to accomplish the tasks of the contract work statement in the alloted six-month period. Within a week after the contract SRI was provided with details of Army AI/R activities to that date.

Q5. What is worth doing?

At the Army Science Board Summer Study strong emphasis was placed on increasing Army effectiveness while at the same time reducing manpower requirements and making equipment easier to operate and maintain. A recommendation was made to examine AI/R. On October 30, 1981, the Army Science Board Ad Hoc Sub-Group on Robotics and Artificial Intelligence (hereafter referred to as ASB) was empaneled. Dr. Irene Peden was appointed Chairperson and the remainder of the Sub-group were distinguished engineers from university and industrial sectors. Dr. Robert Norwood, Deputy for Air and Missile Defense, Office Assistant Secretary of the Army (Research, Development and Acquisition) OASA(RDA), was appointed Cognizant Deputy and Dr. Frank Verderame, DCSRDA, was the DA Staff Assistant. Shortly thereafter the author was also appointed as a DA Staff Assistant.

The ASB was asked to review Army plans, the theory and technology base, and the near term applications in the public and private sectors. They were specifically asked to address: (1) opportunities for the Army to use commercially developed/modified industrial production machines in government-owned facilities; (2) tactical applications of AI/R to increase combat capabilities and decrease personnel requirements (particularly in very hazardous tasks); and (3) application of AI/R to training, personnel, and logistics support areas.

Q3. Revisisted (preliminary review of Army Plan)

On November 23, 1981, the Army AI/R Steering Committee reviewed preliminary inputs for the combined Army AI/R Plan. It was agreed that more time was required to assemble a creditable plan. The current set of inputs had significant gaps and lacked uniformity of presentation. The meeting was attended by a ASSC representative who reported on TRADOC activities. He requested, and received permission, to discuss these applications at a coming AI/R meeting for representatives of the TRADOC Schools and Centers.

Q4. Revisited (TRADOC meeting)

On December 9 and 10, 1981, ASSC hosted a meeting of about 100 representatives from TRADOC Schools and Centers. This meeting represented a milestone in AI/R activities because a cross-section of the TRADOC community was exposed to AI/R intensively for two days. The objective of the meeting was to acquaint the attendees with AI/R so that they could pass on information at their facilities. This would result in a more representative set of TRADOC AI/R development requirements. Major General French, in his opening remarks, expressed an urgency to get the TRADOC AI/R activities properly started in the Schools and Centers. Tutorial briefings were presented by SRI on the subjects of artificial intelligence and robotics. A summary of the DARCOM program was presented and the preliminary inputs to the Army AI/R Steering Committee were reviewed. Attendees were then divided into groups of 8 to 10 individuals who retired to separate rooms to generate their prioritized list of Army needs. Each group had at least one individual knowledgeable about the previous Army AI/R activities. The groups addressed the following areas: combat applications, logistic/support operations; intelligence/training applications, or personnel issues. While the results produced by the groups were not significant at the time, the meeting provided the base upon which TRADOC would produce its contribution to the Army AI/R program.

Q5. Revisited (briefings to ASB)

The initial meeting of the ASB was held on December 15 and 16, 1981. Getting acquainted with the Army's AI/R activities was the first objective. Ms. Amoretta Hoeber, Principal Deputy Assistant Secretary of the Army (Research and Development) opened the meeting and indicated that there was a great deal of activity in the subject areas, but no focus. She tasked the Sub-group to provide guidance for coherent Army Programs. The technical session involved an intensive set of briefings over the two day period. The briefer and briefing topic is provided here to give the reader the flavor for what the Army believed important in AI/R for ASB background material in its study.

Dr. Verderame, DCSRDA, led off the presentations with a brief historical summary of AI/R in DCSRDA leading to the Army AI/R Steering Committee and the activities leading to a future Army Plan for AI/R. He presented a summary of the initial submissions by Army laboratories to the Steering Committee for that plan. Major Peter O'Mara, ASSC, presented the status and

outlined the future objectives of TRADOC in the subject areas. A representative of the Robotics Institute, Society of Manufacturing Engineers, addressed economics of industrial robotic applications. A member of the Force Management Directorate, DCSOPS, briefed on force development. DARPA representatives presented on Intelligent Task Automation, Image Understanding, and Natural Language Understanding programs. A member of DCSPER spoke about concerns of increasing competition with industry, a critical shortage of individuals skilled in high technology, and retention of critical skills. Mr. Charles Shoemaker, HEL, reviewed HEL activities and summarized TRADOC-DARCOM efforts leading to submissions for the Army AI/R R&D Plan. Mr. Fred Michel, Director, Army MM&T Programs, DARCOM, briefed on the MM&T program which will amount to $121 billion over five years. Major Mark Howell, U.S. Army Medical R&D Command (AMRDC), indicated that the AMRDC laboratories would follow AI/R developments but had no resources to participate in the program. Dr. Stanley Halpin, Army Research Institute for Behavioral and Social Sciences (ARI) briefed about on-going and planned programs at ARI related mainly to intelligent man/machine interfaces. COL Maxim Kovel, Assistant Director, R&D Office, OCOE, briefed on-going and planned AI/R activities in the Corps of Engineer laboratories.

The second ASB meeting on February 3 and 4, 1982, continued introductory briefings. SRI briefed on their Army AI/R study for USAETL. Dr. Jude Franklin, Navy Center for Applied Research in Artificial Intelligence, talked about the goals and activities of the Navy's new AI/R Center which deals mainly with matching sets of weapons with sets of targets, expert consultants, message routing, and situation reports. Mr. Ron Hofer, PMTRADE, discussed their activities in training and training devices. The ASB members then viewed two hours of a TV tutorial on knowledge-based expert systems. COL Dave Robinson, Program Manager for the Army Model Improvement Program (AMIP) Office presented a talk on modeling problems and how AI/R can help. A representative from Westinghouse showed some spectacular TV tapes of industrial robots in action at several Westinghouse plants and the Fiat plant in Milan, Italy. Representatives from Honeywell described their contract activities involving robots in GOCO ammunition plants. Mr. Lloyd Root presented U.S. Army Missile Command's point of view on AI/R for Air Defense which stressed the importance of IFF.

At the conclusion of the February 4, 1982 meeting the ASB divided their AI/R world into several important parts and members were assigned to develop more information in these areas. The parts are termed "clusters" and they have the following titles: Autonomous Recognition and Supported C3I Cluster; Automatic Weapons Cluster; Automated Plant Environment Cluster; and the Human Interface Cluster. Other assignments included a summarization and assessment of research issues, soldier-machine interface, management issues, transfer of AI/R research, and personnel problems of the Army laboratories and the impact of the laboratory situation on the capability of the Army to move in the AI/R direction.

The ASB Autonomous Recognition and Supported C3I Cluster met at DARPA on March 26, 1982 for briefings on in-place R&D programs in image recognition. Program briefings were provided by U.S. Army Night Vision and Electro-Optics Laboratory (NVEOL), Martin Marietta Corp., CIA, DARPA, U.S. Army Armament R&D Command (AARDCOM), and the U.S. Army Missile Command (MICOM).

Q4. Revisisted again (TRADOC-DARCOM AI/R recommendation)

An important meeting of the TRADOC-DARCOM AI/R Steering Committee took place on April 7 and 8, 1982. A meeting memorandum, jointly signed by MG French and Dr. Weisz, listed AI/R priorities recommended by the TRADOC Schools and Centers, and HQ TRADOC that were matched with the technical evaluations provided by the DARCOM laboratories. Approximately 100 suggested applications from DARCOM and TRADOC Schools and Centers were screened to select candidates for inclusion in the Army AI/R R&D Plan. The Committee identified 22 mission essential, technically feasible, high priority AI/R applications. These were further organized within four generic categories based on similarities in function and mission. Table 3 lists the recommendations by category.

The Committee recommended a number of crucial guidelines for implementation of the suggested applications: (1) The development of Army robotic systems must be evolutionary if we are to provide early solutions to the many significant combat and combat support problems we now face. We must apply existing AI/R techniques and hardware to develop useful low cost solutions now. Teleoperated remote control and human sensory processing capabilities can be exploited to accelerate the development of specific robotic systems. The role of the human supervisor can be reduced as developments in AI improve machine decision making and sensory capabilities. (2) Army robotic systems should be fault tolerant, modular, and standardized. Major subsystems (sensor packages, platforms, weapons, manipulators) should be designed to allow simple unit replacement for repair or battlefield cannibalization. Collections of standard modules could be configured to meet the demands of specific missions. Improved modules could be substituted without the need for developing

entirely new systems. (3) Interservice coordination of AI/R efforts should begin immediately. The USMC and the Army share an interest in the development of reconnaissance/surveillance robots. A mutual effort in this area would benefit both services. (4) Mobility should be tailored to fit the needs of the supported units. Combat operations may require full sized armored platforms which will be survivable and competitive with modern heavy forces. Small light weight, unarmored systems could be used for reconnaissance and a variety of rear area tasks. Mobile systems should be designed recognizing the advantages of the smaller less expensive requirements of unmanned systems. (5) The Committee recommended immediate accelerated development of the automated ASP, reconnaissance/sentry robot, countermine vehicle, and intelligence fusion. And (6) The activities of the TRADOC-DARCOM AI/R Committee must continue. TRADOC representatives should continue to monitor technologies, educate users, and attempt to identify proponents for potential technological opportunities which may arise. The DARCOM representatives should evaluate, and where possible, implement applications suggested by proponents. The Committee must continue to match TRADOC mission area applications with DARCOM laboratory interests and capabilities as new developments occur in AI/R.

Table 3. TRADOC-DARCOM prioritized AI/R applications

Reconnaissance/Surveillance
- NBC Reconnaissance
- Tactical Reconnaissance
- Remote Sensor Stations
- Sentry Robot

Material Handling
- Automated Ammunition Supply Point
- Automated Loaders
- Refuelers
- Cargo Handlers
- Explosive Ordance Disposal
- Minefield Operations
- NBC Decontamination
- Ammunition Resupply

Artificial Intelligence
- Diagnostic Systems
- Intelligence Fusion
- Command and Control
- Target Acquisition
- Communication Networks
- Target Engagement

Battlefield Systems
- Robotic Countermine Vehicles
- Remotely Activated Weapons
- Intelligent Mines
- Smart Munitions

Q3. Revisited again (Army AI/R Plan progress)

On April 12, 1982, the Army AI/R Steering Committee met to review progress in development of the AI/R R&D Plan. Results of the TRADOC-DARCOM AI/R Steering Committee were presented, as were inputs from the "little three". The Committee scheduled the deadline of 10 June for preparation of the combined Plan.

Q6. Why so many?

The Under Secretary of the Army, James R. Ambrose, was briefed by Dr. Verderame, DCSRDA, on the Army AI/R program on April 21, 982. This briefing contained a description of the detailed planning within the Army at many levels and stressed the recommendations for development resulting from the combined TRADOC-DARCOM efforts as shown in Table 3. The briefing also contained a large list of Army on-going and planned programs in AI/R shown here in Table 4.

The Under Secretary's guidance was that Army planners must concentrate on a small number of AI/R applications in the Army Program. Otherwise he was pleased with coordinated activities.

Dr. Peden presented a summary of the ASB activities following Dr. Verderame. Some of the other attendees included representatives from ASB, ASSC, HEL, OCOE, MRDC, and ARI.

The Secretary of the Army, The Honorable John O. Marsh, Jr., was briefed on AI/R. His recommendations were similar to those of the Under Secretary of the Army and included the guidance to use existing equipment where possible.

Q5. Revisited (ASB continues information collection)

Carnegie Mellon University was visited by the ASB during the morning of April 22, 1982 for briefings and tours of their AI/R programs. In the afternoon the group toured the Westinghouse Productivity Center.

On April 23, 1982, the ASB met to discuss replies to questions they submitted to AMIP, DCSPER, and DCSOPS. The author presented a summary of the SRI draft report on Army AI/R. Dr. Verderame presented his perceptions of the Under Secretary's briefing and then reviewed

the TRADOC-DARCOM progress.

Q7. Can we begin with these few?

The Army AI/R Steering committee met on May 10, 1982 to select a small number of demonstrators as directed by Secretary Ambrose for a near-range Army plan. Six program demonstrators were chosen to initiate a coordinated Army AI/R Program. The titles of these these demonstrators and the responsible agencies were: (1) Reconnaissance Vehicle - DARCOM; (2) Automated Ammunition Supply Point - DARCOM; (3) Tank Integrated Intelligent Interface - ODCSPER/DARCOM; (4) Training - ODCSPER; (5) Terrain Analysis - OCOE; and (6) Medical Aids on the Integrated Battlefield - AMRDC.

Table 4. Army AI/R programs funded and unfunded.

Funded Near-term	Funded Mid-term	Funded Far-term
Intelligent Mines	NBC Recon, Aerial	Image Processing
Chemical RPV	TEARS	Auto Tracker
NBC Recon, Ground	Demo M110 Loader	VHSIC/VLSI
Decontamination	Robot Spt for ASP	Aviat Work Reduct
Advanced Fuzing	Smart EOD Robot	Countermine Vehicle
Auto Loader	Misl & Rckt Load	Foward Ammo Hndlng
Smart Proj (3.5M)	Rapid Excavation	Container Hndlng
Tank Fire Control	Adapt Intel Intrfc	Biological Sensors
Helicopt Gnd Surv	Image Processing	Airbrn Mine Detection
Effective Assess		Auto ASP
Refuling Systems		Mobl Sensr/Obs Avoid
Auto Water Analysis		Countermobility Robot
Adv Tank Diagnosis		Vehicle Self Defense
Adv Tank Prognosis		
Maintenance Tng Aid		
Vint 2 Oper Intrfc		
Imagery Interpret		
Tgt Rec & Corr		

Unfunded Near-term	Unfunded Mid-term	Unfunded Far-term
Intl Knowledge Base	Passive Surveillance	Ident Friend/Foe
Intl Data Base	Auto Tracking	Easy Gunner
Robot Smoke Generator	Prog Grenade Launcher	FC Processor
Flame Thrower	Auto Sml Arms Maintenance	Robotic Contrl
ROBAT	Tank Engine Replacement	Gunner Aid
Intl Fusion Aid	Brigade Planning Aid	Auto Air Defense
		Supply & Recon Sys
		Fire Fighting
		Close-in Recon
		Auto Load in NBC
		Rescue, Removal
		Medical Evacuation
		Active Armor
		Expert Systems
		Planning Aids

A tasking letter signed by Dr. Lasser, DCSRDA, on June 2, 1982, officially notified agencies of their responsibilities and requested that plans be submitted by June 21, 1982. The plans were to include a detailed description of the near-term demonstrator; funded and unfunded requirements for the near-term demonstrator; and a preliminary outline of longer term technology enhancements for the demonstrator. In addition the letter asked that planning efforts toward the final Army long-term AI/R program continue.

Q1. Revisited again (SRI study completed)

Early in June 1982, the SRI report entitled, "R&D Plan for Army Applications of AI/Robotics" was delivered. It represented a considerable achievement for a six month study where no previous experience base existed. It indicated that in most cases AI/R technologies lack maturity necessary for preparation of detailed R&D plans for autonomous battlefield systems in the 1990's. It pointed to the need for a significant amount of basic and applied research needed to demonstrate concept feasibilities.

The report lists one-hundred potential application concepts and indicates that this is but a sample from a very large population. These one-hundred example concepts were then used to define ten broad application categories for combat and combat support purposes. At this time, however, the significance is not in the individual applications or the application categories as much as the general applicability of AI/R concepts to the domains of combat and combat support. The initial indication seems to be that if applicable technologies are properly addressed, the potential applications for future combat and combat support systems may be limitless. The report indicated 97 specific research topics, with many being common to a number of applications within a category.

A summary of this report is presented by Dr. David Brown, et. al., in these proceedings. The report is available from the Defense Technical Information Center, Cameron Station, Alexandria, Virginia 22314.

Q7. The demonstrators

On July 8, 1982 the drafts of all Demonstrator plans had been received at DCSRDA and a meeting of representatives of the responsible agencies and ASSC was called to begin preparations for briefings. It was decided to combine the Reconnaissance Vehicle Demonstrator and the Terrain Analysis Demonstrator. The five Demonstrators, if funded, will be demonstrated within two years and further development will be dependent upon evaluations at that time. The objective is to begin now with a few priority systems.

The Demonstrators will be outlined briefly to convey their basic nature. In each case autonomous systems are desired in the long-term, but todays technology dictates a beginning with interactive systems. Technology enhancements have been identified for each demonstrator. These enhancements point to automated capabilities in the long term.

Reconnaissance vehicle demonstrator with terrain analysis. It is proposed to demonstrate the capability to plan and conduct teleoperated reconnaissance vehicle operations for representative battlefield missions. The demonstration will center around a remotely controlled reconnaissance vehicle and its teleoperating control systems. Control of the vehicle in the performance of its battlefield tasks is divided into (1) operation of the vehicle and (2) operation of the vehicle payload in the performance of reconnaissance functions. The teleoperated vehicle will have remote controlled reconnaissance imagery and non-imagery sensors, stereo cameras for remote navigation, a position/navigation system, remote control systems, and associated communication systems. Control of the reconnaissance vehicle will be accomplished from two teleoperated stations in a remote van. The reconniassance station will be composed of sensor displays, microcomputers, remote controls, sensor signal processor controls, and a military intelligence data base. The vehicle teleoperators station will have a stereo-image display, terrain graphics displays for route planning operations and monitoring vehicle location, microcomputers, teleoperator controls, and terrain data bases. Both stations will have provision for voice actuated displays.

Automated ammunition supply demonstrator. It is proposed to demonstrate rapid unloading of ammunition modules in a battlefield environment. Within a newly proposed ammunication resupply system, industrial robot subsystems, e.g., Unimation 4000, will unload newly received ammunition of various types, sort the ammunition, and pack and issue the ammunition quickly and efficiently to a user. Mechanization that includes the integration of robots with other automated materials handling equipment, conveyances, and machinery, with computing process control, is the key to increased efficiency.

Tank integrated intelligent interface demonstrator. It is proposed to demonstrate an intelligent interface for a vehicle (tank) defense system. The objective of this interface is to provide the tank commander with the proper information when he needs it. The system will be sensitive to user characteristics, and knowledgeable about the user's tasks and the situation. It will treat the threats, offensive and defensive options, route planning, fields of fire, target selection, and coordinated maneuver. The system will contain displays, microcomputers, data bases and voice I/O.

Training demonstrator. It is proposed that an intelligent maintenance training system be demonstrated. The system will be centered around an interactive computer-assisted instruction software module which will teach maintenance and troubleshooting skills. Maintenance concepts such as how a machine works and its trouble-shooting symptoms will be taught by a system robust enough to handle mixed initiative pupil/machine dialogues at a pace adapted to the user potentials.

Medical aids on the integrated battlefield demonstrator. It is proposed that a medical aids demonstration involve training, professional development, diagnosis and treatment, remote health care, and casualty handling. The training module would be an interactive computer-assisted instruction system that would deal with medical emergencies. A student

would assess the situation, make emergency care choices, and give aid. The professional development module would employ a video disk to rapidly present a trained physician with new surgical techniques and treatment methods. The diagnosis and treatment module would be an expert system with a trauma data base or an expert system for sick call. Remote health care would involve remote diagnostic facilities for battlefield-acquired radiographs or other medical sensors. Casualty handling would involve an intelligent planning system which organizes a casualty handling and evacuation plan based upon casualty assessment and transportation and facility resources.

Q8. What else is there?

Early in July 1982, the Manufacturing Studies Board of the Assembly of Engineering, National Reserach Council, National Academy of Sciences (NAS), began a study to identify a strategy for using AI/R to replace or multiply the effectiveness of human combat and support resources. The study is being conducted for DCSPER and DCSRDA and will be completed in twelve months. Included in the study scope will be potentials in the combat and combat support domains but emphasis will be given to combat support. NAS will approach the study by selecting a 12-member committee to conduct the study, plan and conduct a workshop, and prepare a final report.

Q5. Revisited again (ASB completes visits and evaluations)

In addition to visiting Carnegie Mellon University and Westinghouse Productivity Center on April 22, 1982, members of the ASB also visited the following organizations: Massachusetts Institute of Technology, May 21, 1982; SRI International, June 1, 1982; Stanford University and Hughes Aircraft, June 2, 1982; Northrop (Factory of the Future), June 3, 1982; and National Science Foundation, June 23, 1982. They were briefed by the U.S. Army Foreign Science and Technology Center on Eastern Bloc AI/R activities on June 27, 1982.

On July 28-29, 1982, the ASB met to prepare a preliminary draft of their final report. Their agenda included priortizing the Army Demonstrators, reviewing [illegible]ster submissions, and developing a set of AI/R recommendations for the Army. The ASB final report will be submitted in September 1982.

Future

The Army will continue to move ahead with its AI/R efforts. Their [illegible] interest in the laboratories at present and this interest will grow. In-house activities will increase as personnel become more familiar with the new technologies. In the near-term, funding decisions for the Demonstrators will be made. The nature of these decisions is not 'if to fund' or 'what to fund' but 'when to fund'. The high priority near-term demonstrators are expected to provide a necessary impulse for activities leading towards long range AI/R programs.

Optimism for a bright future of AI/R in the Army stems from general R&D objectives and related AI/R expectations. For example, assist or replace personnel in decision-making or labor intensive tasks. Or reduce personnel exposure in dangerous or stressful areas while retaining the capability to accomplish necessary tasks. And there are many other examples of Army-related functions where AI/R systems offer potential solutions. In the near-range these systems will be relatively unsophisticated, but enhancements from research results will lead to more autonomous systems. The next ten years will be a challenging period for those involved in Army AI/R programs.

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A historical summary of the Army activities in artificial intelligence and robotics (AI/R) in the last one and one-half years indicates Army interest in AI/R from the laboratories to the Secretariat. Numerous funded and unfunded efforts are now planned by the laboratories even though AI/R technologies lack maturity necessary for autonomous battlefield systems in the 1990's. The potential applications of AI/R systems to Army needs appear to be limitless. DARCOM and TRADOC have prioritized AI/R requirements and plans for five high priority Demonstrators have been prepared. These demonstrators reflect the need to get started with todays technologies. Technological enhancements provided by additional research and develop-

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